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SANITARY GUIDELINES AND MAINTENANCE INSTRUCTIONS FOR THE POTABLE WATER SYSTEM OF HOTEL-SHIP SUNBORN GIBRALTAR

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ABSTRACT

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SANITARY GUIDELINES AND MAINTENANCE INSTRUCTIONS FOR THE POTABLE WATER SYSTEM OF HOTEL-SHIP SUNBORN GIBRALTAR

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Finnish company Sunborn International is completing construction works at the time of writing this study for their hotel-ship Sunborn Gigraltar, located in Gibraltar (UK). This thesis was commissioned for doing research of how to storage potable drinking water according to the sanitary safety guidelines of World Health organization (WHO) and ensure constant and healthy water supply at all times for customers.

Before starting water supply onboard, should be WHO guidelines studied and conditions of municipal water network settled clear from government of Gibraltar. Also, whole ship´s sanitary system piping should be inspected and used materials be checked to avoid rapid corrosion by local municipal water. As well, make sure that back flush is not possible in any operative mode because system doesn´t have separate technical water system for technical equipment. Also, to ensure continue supply of water without sudden outages should be water firstly storage in tanks onboard. For solving these issues should prepare maintenance instructions for potable water system.

Continues supply of potable water is vital for the hotel operation. Therefore, for a result and according to the maintenance instructions, vessel maintenance staff should keep close attention of water quality, and samples should be taken to the laboratory testing on regular basis, and as well keep system operative and clean of bacteria.

TIIVISTELMÄ

KYMENLAAKSON AMMATTIKORKEAKOULU
Merenkulun koulutusohjelma / Meri-insinööri

LEPPÄNEN, HENRIK

SANITEETTITEKNISET HUOLTO-OHJEET SUNBORN GIBRALTAR HOTELLILAIVALLE

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Avainsanat laiva, juomavesi, WHO, makeavesijärjestelmä, juomaveden käsittely ja varastointi tankkeihin, laaduntarkastus ja valvonta, pilaantuminen, tankkaus

Suomalainen yritys Sunborn International varustelee työn kirjoitusajankohtana hotelli-laivaa Gibraltarilla, Espanjan mantereen etelä-kärjessä. Tämä opinnäytetyö käsittelee hotellilaivaa koskevia säännöksiä juomaveden käsittelystä, varastoinnista ja veden jakelun varmentamista katkoksien varalta.

Ennen kuin hotellilaiva voi aloittaa vedenjakelun, pitää ottaa selvää WHO:n säännöistä ja Gibraltarin kunnallisen vesiverkoston toiminnasta ja veden laadusta, sekä tarkastaa koko laivan putkistojärjestelmä. Myös putkistomateriaalien pitää sopia Gibraltarin happamalle käänteis-osmoosilla tuotetulle vedelle. Takaiskut pitää estää laitteilla niin, ettei pumpuilta ja muilta makeavesijärjestelmän ulkopuolisilta laitteilta ole mahdollisuutta saastuttaa juomavettä. Tämä järjestely täytyy tehdä, koska tällä hotellilaivalla ei ole erillistä teknisen veden järjestelmää. Lisäksi vesi pitää ensin varastoida tankkeihin ja ennen jakelua käsitellä asianmukaisin menetelmin WHO:n saniteettisääntöjä noudattaen.

Varastotankeilla varmistettu jatkuva juomakelpoinen veden jakelu on yksi avainasioista viiden tähden hotellilaivalle. Siksi huoltohenkilökunnan on päivittäin tarkkailtava veden laatua ja lähetettävä viikoittain näytteitä laboratorioon tutkittavaksi laaditun huoltosuunnitelman mukaisesti.

TERMS AND ABBREVIATIONS

Hotel-ship	Vessel designed mostly to be used as hotel and to be moored for a period at pier, usually close to the city attractions, but equipped with propulsion for transfers by waters to other cities. This new concept has no marine classification yet.
WHO	World Health Organization
MCA	Maritime & Coastguard Agency
FW	fresh water
WSP	Water Safety Plan
NRV	non-return valve
ppm	parts per million
IAS	Integrated Alarm System
AFT	the aft side of the vessel
P&S	port side and starboard side of ship
Hi-Fog	Fire protection system that accomplishes fire suppression with water mist.
UN	United Nations
UV	ultraviolet light
MS	motor ship
Air cab	Equipment for isolating physically potable and non potable water by supplying air space between piping.
GT	gross tonnage
Technical water	Non-potable water to be used only for ship`s technical equipment.
IAS	integrated alarm system

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1 INTRODUCTION

Sunborn International has supplied a hotel-ship to be permanently moored and used for hotel and restaurant purposes in the Ocean Village of Gibraltar (UK). It needs there reliable potable water network. Source water will be supplied from municipal network for filling up the onboard storage water tanks. These tanks are needed instead of direct pressurized municipal supply because history has shown frequent outages of water supply. This hotel-ship will be classified with a five-stars rating and therefore should not exist any outage of water supply for guests at any time. Therefore, onboard storage tanks and water treatment system for the potable water supply should be installed.

World Health Organization (WHO) sanitary regulations and guidelines should be followed for the storage and supply of potable drinking water. These sanitary regulations should be considered and followed in the early stage of ship design process sanitary system layout to be completed. All used materials and components, as well as, the design and manufacturing of the piping, should meet these regulations. Commissioning of the system to be followed after piping completed. It means pressure testing and proper washing of the potable water tanks, flushing of the pipelines and the bunkering hoses, and it should be done as instructed by WHO. Prior to system start-up, testing and certification of potable water should take place by an independent laboratory. When system is in use, water quality and system functionality should be checked according to the maintenance instructions.

Generally, the infection of waterborne diseases should be seriously noted when supplying of drinking water from the tanks of ship or floating hotel, because hundreds of people may become sick. Therefore, the daily monitoring of the sanitary system is needed, and periodical testing of potable water quality must be done as per WHO guidelines. Also, all data must be recorded into vessel water log book on daily basis. The Master of the vessel is fully responsible for the potable water quality onboard but often delegates the actual job to the engine department officers because the production of the potable water and the maintenance of the water treatment plant in most cases is been done by engineering crew. For hotel-ships moored permanently at the pier, this job is required to be done by qualified plumber or vendor, and the hotel manager or the maintenance manager is fully responsible for over all quality of the water supplied.

2 GUIDELINES FOR STORAGE AND SUPPLY OF POTABLE WATER

2.1 Health risk caused by contaminated water

In the 1970 – 2003, WHO listed over a hundred cases onboard ship`s of potable water contaminated and circa in every fifth of them, contamination is caused by waterborne route with pathogens from human or animal. Also, in some cases the outbreaks of chemicals caused poisoning of the water. In addition, poorly managed bunkering has caused problems:

- contaminated bunker water from port
- cross connection between potable and non-potable water
- incorrect loading procedures because of unqualified staff
- bunkering hose or connector dirty
- poorly designed or constructed tank

[2] (WHO 2011, Guide to Ship Sanitation, 16)

Chart 1. Outbreaks of waterborne diseases with the ships 1970 – 2003.[2] (WHO 2011, Guide to Ship Sanitation, 16)

Pathogen/toxin	**Number of outbreaks**	**Number of passengers and crew members affected**
Enterotoxigenic Escherichia coli	7	2917
Norovirus	3	788
Salmonella typhi	1	83
Salmonella spp.	1	292
Shigella spp.	1	690
Cryptosporidium spp.	1	42

Giardia lamblia	1	200
Unknown agent	5	849
Chemical water poisoning	1	544
Total summary	**21**	**6405**

2.2 Controlling health authorities

2.2.1 WHO (World Health Organization)

WHO is the organization concerned of public health and it is responsible for the leadership on global health matters, setting of the guidelines and the standards, monitoring and production of the health data and providing technical support to resolve issues and achieves of better overall public health. WHO is working under UN (United Nations).[11] (WHO website)

2.2.2 MCA (Maritime & Coastguard Agency)

MCA is an organization providing services for better maritime safety, monitoring of the training and certification of the seamen, creating guidelines for the food and the fresh water on ships and over all providing of the environmental safety, safer practice, safer ships and cleaner seas. MCA follows guidelines of WHO.[12] (MCA website)

2.3 Potable drinking water quality

2.3.1 Water Safety Plan (WSP)

Water Safety Plan is based on strategies of health targets and for hotel or ship`s management ´step by step´ instructions to identify potential risks in the water supply chain, all the way from the source to the consumer. Also, it includes the surveillance of the water quality and the documentation for the public health context and the health outcomes. WSP mainly consist of:

- System assessments
- Monitoring and corrective actions
- Management plan and control measures

[5] (WHO 2004, Rolling Revision of the WHO Guidelines Drinking-water Quality, 16)

2.3.1.1 System assessments

The purpose of the system assessment is to make sure health based targets are taken into account and controlling measurements are taken. This means regular inspections of water quality. All precedent tasks, is to ensure health aspects, avoid risks and operative actions which may affect of potable drinking water quality. System assessments mainly consist of:

- acceptable water quality for consumers
- requirements of water source origin
- water treatment plan and actions

[5] (WHO 2004, Rolling Revision of the WHO Guidelines Drinking-water Quality, 17)

2.3.1.2 Monitoring and corrective actions

The risk of contaminated water should be avoided by planning the monitoring in such a way that, contamination will be detected so early stage, not possible to reach consumers onboard. Samples of water must be taken and unused lines should be flushed in a way that no aerosols enter piping. Also, the water treatment equipment, the bunkering hoses, the piping system and the back flow prevention devices should be checked or repaired and flushed on regular basis.[5] (WHO 2004, Rolling Revision of the WHO Guidelines Drinking-water Quality, 17)

2.3.1.3 Management plan and control measures

Management plan must to ensure the quality of the water constantly meets the health requirements. Meaning, WSP should include the assessment of the source water loaded in to ship or hotel by correct water treatment methods operated by qualified staff, and make sure re-contamination prevented during storage or after repairs or

distribution. The main issue is to keep positive pressure in the sanitary system to prevent the back flow.[5] (WHO 2004, Rolling Revision of the WHO Guidelines Drinking-water Quality, 17)

2.3.1.4 Monitoring of quality and corrective actions

Chart 2. Monitoring of the quality and corrective actions.[5] (WHO 2004, Rolling Revision of the WHO Guidelines Drinking-water Quality, 17 - 18 and 22 - 23)

Hazardous event	**Controlling**	**Monitoring**	**Corrections**
Cross connection with non-potable water	Whole vessel to be inspected to prevent cross connections, starting from as built drawings and piping system installed onboard	Whole vessel sanitary water system to be inspected	Repairs of cross connections and drawings to be updated, after operation completed
Pipe leakage	Make inspection plan to find out spots with high risk of high-cost damage, and daily inspect places where water will first flow in case of leakage	Mainly visual inspections but also moisture measuring equipment is useful, proceed continuous line pressure monitoring and keep log book	Repairs and then after pressure testing
Back flow preventers to be installed in the places with possibility of back flow by reduced	No possibility of contamination of potable water	Testing and maintenance of the back flow preventers, and the inspection of type and work method of the originally	Replace back flow preventer or add more if needed, but better study first correct fitting type before

pressure in pipeline		installed equipment to ensure proper functionality	purchasing
Constant leakages in piping or leakage in tank	Inspection of whole system first, then after plans and schedules for the maintenance and repairs, including estimation of total costs	Periodical testing of pipe wall thickness and monitoring of number of leakages by time period	Recommended way to start is first to take off damaged pipes and for the rest of piping to do proper pressure testing to find out weak spots
Potable water contamination	Contaminated water should never enter delivery network, and bacteria levels should never rise without controlling measures taken	Always after repairs or maintenance should be water samples taken for independent laboratory testing	Super-chlorinating and flushing of whole system according to the sanitary health instructions
Piping material insufficient, leads to contamination from toxic or dangerous metals, or too high quantities of minerals in the sanitary system	Material specification of piping need to be checked to ensure quality of supplied potable water	Samples of water quality should be taken for the measures of toxic and minerals	Replacing of pipes
Disinfection insufficient	Chlorine < 0.2 ppm to prevent regrowth	Daily monitoring of pH and temperature and	Continuo monitor and investigate the cause if

	of bacteria	chlorine by hotel or ship`s crew	problems regenerate

2.4 Source water supply from shore

Water will be supplied for hotel-ship Sunborn Gibraltar from the municipal supply network of Gibraltar by a hose from local water supply connection. Plans for the construction of the water loading facilities should be submitted to Gibraltar health authorities for review. These plans should include information of the:

- location and size of distribution lines
- location and type of line valves, back flow preventers and hydrants
- details of protecting outlets, filling hoses and storage facilities

Hydrants, faucets and taps should be marked clearly with capital letters ´POTABLE WATER´ and ´NON POTABLE WATER´. The bunkering hose should be placed as high as sea water level that it will never be submerged. As well, outboard hydrants should be constantly covered and placed in a way of no possibility to get in touch of any sea water, rain water or waste of the ship. The bunkering hose should be designed specially for the purpose, painted blue and marked clearly with capital letters ´POTABLE WATER HOSE ONLY AND FITTINGS STORAGE´. The hose should be a self-draining type. The filling line, where the bunkering hose is connected, should have connectors or flanges marked with capital letters ´POTABLE WATER FILLING´ and location of minimum 46 cm above from the actual deck, and prefer to be inside doors in a clean environment.

Filters should be used for better drinking water quality of bunkered water and always if water has even a small level of contamination.

Reference for chapter 2.4: [6] (MCA 2006, MGN 397 (M+F), 15) and [5] (WHO 2004, Rolling Revision of the WHO Guidelines Drinking-water Quality, 18 – 19 and 27)

3 WATER QUALITY POLICY AND MONITORING ONBOARD

3.1.1 Safe and correct system operation

The system should operate the following temperatures to ensure healthy and safe use of water distribution:

- cold water storage temperature should be below 25° C, prefer 20° C or below
- hot water storage and distribution temperature should be in range of 60 – 65° C
- hot water service return temperature should be 50° C or more
- hot water should be heated up to 65° C prior to delivery for consumers
- hot water blending valves should be set to 41 – 46° C

[7] (Redditch Borough Council, Water Services Log Book, 2)

3.1.2 System checks

The system should be checked on regular basis to maintain healthy and safe operation:

1. Weekly check: If blended water supply outlets are equipped onboard then check and record blended water taps outlet is attained circa 43° C in time of one (1) minute, but note different settings for items of:
    a. Bidets 39° C
    b. Showers, washbasins and unattended baths 41 – 43° C
    c. Attended baths 46° C.
2. Weekly check: Sentinel taps to be measured on spots basically at the first and in the last in the system circulation. These spots are designed and clearly marked and class approved for the water distribution system, and can not be changed. Check and record water temperature from sentinel taps:
    a. Hot water should be over 50° C after one (1) minute of flushing
    b. Cold water should be below 25° C after two (2) minute flushing

i. Recommended 20° C or below, but not required.

3. Monthly check: Check and record temperatures from the calorifier:
    a. Flow from the calorifier in limits of 60 – 65° C
    b. Return back to the calorifier at minimum of 50° C
4. Six (6) monthly check: Measure and record temperatures of potable water in the storage tanks:
    a. Incoming water should be below 25° C
    b. Remotely measured from inside of the tank should be in all cases below 25° C
        i. Recommended 20° C or below, but not required.
5. Six (6) monthly check: Measure and record cold water temperature rise between the tank outlet and return, it should be inside 2 – 3° C limit.
6. Annually check: Water sample from the calorifier drain point, it should be clear and free of debris.
7. Annually check: Open and inspect the calorifier and clean it if necessary.
8. Annually check: Compare between cold water tap outlets temperatures, these should all be inside 5° C limit.

[7] (Redditch Borough Council, Water Services Log Book, 3 - 4)

3.2 Storage of potable water onboard

The potable water should be stored in coated tanks and the coating materials must be as instructed by manufacturer. Also, when the tank to be repaired should manufacturer`s instructions be followed. Tank inner surfaces should be cleaned with 50 ppm chlorine solution and it must be done on regular basis, at least annually or always after repair or any contamination of the water.[6] (MCA 2006, MGN 397 (M+F), 15) and [13] (MCA 1986, Department of Transport, Doc. M.1214, 5)

The ship´s water storage should be always enough at least of two (2) days of usage and storage volume should be calculated for the each vessel type separately.[6] (MCA 2006, MGN 397 (M+F), 15)

Some principles for the tank volume calculations could be average of 220 Litres per person per day. This unofficial reference was received from the engineering crew of the Royal Caribbean International passenger ship, MS Mariner of the Seas.

The water should be circulated all the time in tanks, and this circulating is concerning also the whole potable water system onboard. Preferably, the water temperature in tanks should be 20° C or below but according to the sanitary guidelines must not exceed 25° C. If the water temperature exceeds 25° C for two (2) days or more, tanks should be discharged and super-chlorination washing take place.[7] (Redditch Borough Council, Water Services Log Book, 2)

Good solution of free active chlorine level in tanks should be 0.2 mg in litre of water and it is equal measure of 0.2 ppm[10] (www.unitconversion.org). If the chlorine levels are under that should be then extra free chlorine added to meet the standard. The pocket size colorimeter is handy for the measuring purpose, but it must be tested for the measuring accuracy of each month by using a chlorine standard kit.[6] (MCA 2006, MGN 397 (M+F), 13)

3.2.1 Storage tank maintenance

Clean and protective clothing and footwear should be used while carry out maintenance and inspection of the tanks. Also, the operating person should not be infected of any communicable disease or skin infection.[6] (MCA 2006, MGN 397 (M+F), 16)

Chart 3. Storage tank maintenance.[6] (MCA 2006, MGN 397 (M+F), 16) and [13] (MCA 1986, Department of Transport, Doc. M.1214, 5 – 6)

Maintenance work	**Interval**
All the water to be drained from the tanks prior to re-filling, and the tank bottom should be flushed clear for the sediment without opening the tank top	Every six (6) months
The tanks must be opened and all surfaces cleaned properly with 50 ppm free	Every twelve (12) months or every time

chlorine solution and then flushed with potable water prior to re-filling with 0.2 ppm free chlorine solution, also inspection of the tank construction must be carried out for cracks and coating damages, and repairs should be done if necessary following the manufacturer`s instructions	tank is infected
The whole sanitary water system including the tanks should be charged for 12 hours with 50 ppm chlorine solution and then properly flushed prior re-filling with 0.2 ppm chlorine solution	When re-fitting or dry docking
Pressure testing must be done for all the tanks, after the testing the tanks should be properly flushed prior re-filling with 0.2 ppm chlorine concentration	No greater than five (5) years and always to be done after tank repair or damage

3.3 Disinfection by super-chlorination

1. The tanks are drained and piping system is completely empty.
2. Sanitary system is checked of possible leaks and repairs are done if necessary.
3. Tablets or liquid are calculated for matching the water capacity of the tanks to match chlorine solution of 50 ppm (50 mg/Litre)[10] (www.unitconversion.org):
    a. Tablets of SANICHLOR, HAZ-TABS 1,8g
        i. Use 50 tablets for 1 tonne of water to match chlorine solution of 50 ppm (50 mg/Litre)
    b. Liquid of Sodium Hypochlorite 10%
        i. Use 0.5 litre of Sodium Hypochlorite 10% for 1 tonne of water to match chlorine solution of 50 ppm
4. Dissolve the tablets in a clean container with fresh potable water.

5. Add solution a. or b. into the tank when ¼ to ½ full, prior to filling with clean potable water.
6. Circulate the water in the sanitary system by pumps.
7. Open all taps and hydrants and let the water flow until a strong smell of chlorine noted, and then all closed to keep solution activated from 8 to 24 hours.
8. Open all taps and hydrants and let the water thoroughly empty the system.
9. System is flushed with potable water.
10. All taps and hydrants are closed.
11. Fill-up the system with potable drinking water of 0.2 ppm solution of chlorine.
12. Chlorine levels are measured.
13. Local port Health Officer is called to carry out testing.
14. Water log book is filled and documents are archived.

[8] (City of London, London Port Health Authority, A Procedure for the Super-chlorination of Ship's Potable Water Tanks)

3.4 Maintenance of potable water distribution system

Chart 4. Potable water distribution system maintenance.[6] (MCA 2006, MGN 397 (M+F), 16)

Item	**Maintenance work**	**Interval**
All potable water filters	Cleaned according to manufacturer`s instructions or changed when necessary	Monthly but preferably biweekly, or according to the manufacturer´s instructions
UV water purifier	Cleaned according to the manufacturers instructions	According to the manufacturer`s instructions
Calorifier	Opened for inspection and cleaning, and prior draining the temperature should be	Annual inspection, or according to the

	kept at 70° C for an hour for destruction of possible bacteria	manufacturer`s instructions
Shower heads and taps onboard (also, crew change rooms)	If accommodation not used for an week, flushing should be done to avoid contamination by back-flush in the line which will occur if the line pressure drops	To be weekly checked and always flushed if accommodation has used for a week
Shower heads, hoses and taps	Cleaned with 50 ppm chlorine solution	Every 3 months
Potable water bunkering hoses	Flushed properly before filling the hose with 50 ppm chlorine solution for at least an hour prior to draining, then stored it in a clean locker onboard	MCA guideline is every 6 months but preferably more often, and always if any particle or dust enters the hose

4 SANITARY DESIGN PRINCIPLES ON VESSELS

4.1 Piping

The sanitary potable water piping should be painted blue or marked with blue stickers as 'POTABLE WATER' on both sides of the pipe before and after any fitting by intervals of maximum 5 meters in piping line. The bulkheads and deck penetrations are marked similarly. Also, the direction of the water flow should be indicated with an arrow and it is important to mark hot and cold differentia. Stickers are handy for the marking purpose because all needed information can be in one sticker and it is quick to place. The guide for marking potable and non-potable water outlets and hoses can be found in chapter 2.4.

The potable water piping should not penetrate or be located under of a tank or non-potable piping. Also, surface connection with non-potable liquid should be avoided. Most importantly, potable water piping should never submerge with bilge or sea water.

Every time the pressurized potable water is connected into the non-potable equipment or pump, the back-flow of non-potable water must be avoided by installing back-flow preventers or air gabs (´water brakes´). It is recommended to install air gab because it will separate all potable from non-potable water. The back-flow preventer type non-return valve (NRV) has a risk of failure because it can be stuck and constant checking is required. This takes time but in some cases it is the only choice, if technical water not supplied onboard, and needed supply of pressurized water for non-potable equipment. If these NRV`s are used, should be install two (2) of them on a line because if one of them fails, the other one still be working. In accordance with good shipbuilding practice, the vessel should have always separate technical water system. Also, the potable water lines should not have any connection to the non-potable lines or drains.

Back-flow preventers should be installed in:

- swimming pools, hot tubes and whirlpools
- hospital and laboratory equipment
- air conditioning piping and expansion tanks
- boiler tank and pump and feed water connections
- pipe connections into waste tanks
- spray water hoses in hair saloons
- water fire fighting systems
- toilets
- connections between potable and non-potable water
- showers and bath tubes (recommendation only)

Submerging pipe lines or non-potable piping should not have any connection to the potable water piping in:

- all ballast systems
- any grey or bilge or black water areas

- in the international shore connection

The back-flow preventers should be located in such a way that service can be done easily and for the maintenance schedule, should be followed the guidelines of the manufacturer`s instructions or WSP`s. All materials and equipment installed must be classified for the potable water usage. WHO has a list of suitable materials and installation methods, and the manufacturer or the supplier of the equipment should have a certificate of approval for the potable water usage. If hot and cold water lines are close to each other, thermal isolation should be carried out.

4.2 Potable water tanks

The potable water onboard should be stored in one or more tanks witch should be designed according to the sanitary rules and protected from any contamination coming from outside. Also, tank top should be equipped with a hatch for easy access to the tank.

Tank arrangements:

- the potable water tanks should be independent of ship`s hull
    - also, no common partition of the tank structure between the other tanks
- when connected to the toilet flushing system or when potable water be used as feeding water for the non-potable technical equipment, the water cabs should be used for preventing the back-flow, but if that is not possible then the line must be equipped with suitable:
    - vacuum breaker (for toilet flushing)
    - NRV`s (preferably two (2) aligned in a line)
    - back-flow preventer which has been classified for the marine use

Tank siting regulations:

- the tanks should be located above the double bottom
    - exception for the emergency alternative drinking water reserve which can be located in the double bottom

- the tanks should be independent from the other non-potable tanks and should be isolated from the ship´s hull
    - if tanks are not independent and has physical connection to the ship´s hull, the construction of the tank should be all-welded and suitable in all aspects prevent any damage or water contamination – *this is not generally recommended solution*
- the inspection and the maintenance staff should have easy access into the tank with all equipment needed
- the tank should not be situated in the forepeak because of possibility of damage by collision or heavy surging or pitching
    - exception for a small vessels under 2500 GT; the tank can be situated inside the forepeak but only if a special construction to be made under the bottom of the tank by filling and smoothing with cement or other suitable compound and the tank construction is all-welded

Tank construction regulations:

- there should be no cross-connections between non-potable tanks or non-potable piping
- the non-potable piping should not enter the potable water tank
- no toilet or laundry or any other equipment or piping containing other than potable water should be located above the crown of the potable water tank
- the airing of the tank and the manual gauging system should be protected from dust or particles or any other contamination
    - the air pipes should of swan-neck type fitted with a cover and approved for the marine usage and should be located high above the deck to prevent non-potable water access into the tank
    - the manual gauging equipment for the potable water must be separated from the non-potable

- the remote level gauging must be arranged so, there is no physical connection to the potable water except, marine use certified stainless steel equipment or sight glasses
    - the level gauging systems operating by air supply for the measuring must be isolated in a way, the air must not access into the tank

Tank inner coatings:

- before starting the installation of the coating of the new stainless steel tank, all surfaces should be metal-brushed and cement-washed and primed to be sure the coating will stick tightly on the surface and last long
- the coating should be made from epoxy based materials classified for the potable water tanks and the marine use
- the repairs, maintenance and cleaning of the coating should be done in accordance with manufacturer´s or supplier´s instructions
    - for cleaning of the tank, a solution of 50 ppm of chlorine in the potable water is commonly used [instructed in chapter 3.3]

Reference for chapter 4: [5] (WHO 2004, Rolling Revision of the WHO Guidelines Drinking-water Quality, 25 – 29) and [13] (MCA 1986, Department of Transport, Doc. M.1214, 3 – 7)

5 HOTEL-SHIP SUNBORN GIBRALTAR

5.1 Vessel specification

The ship was under construction at the time of writing this thesis and changes for the final specification may come later.

Chart 5. Specification, March 2014 (Lloyds Register).

Vessel Name	SUNBORN GIBRALTAR
IMO number	9475272
Vessel type	Passenger Ship
Class society	Lloyd's Shipping Register
Year of build	2014
Builder	Boustead Naval Shipyard, Malaysia
Call sign	PCQM
MMSI	246879000
GMDSS:	A3
Length	141.20 m
Breath	22.76 m
Draught	4.00 m
GT	15000
DWT	2500
Main Engine	4 x Caterpillar C32 Marine Engine
Engine power	3496 kW (4 x 874 kW)
Propulsion	2 x Schottel SRP Rudderpropeller
Propulsion power	1840 kW (2 x 920 kW)
Home port	Assen, Holland
Flag	Netherlands
Owner	Sunborn International, Finland.

Figure 1. Hotel-ship Sunborn Gibraltar. (Sunborn International)

6 SUNBORN GIBRALTAR SANITARY POTABLE WATER SYSTEM

6.1 System description

The system is designed to serve all consumers with sanitary fresh potable water [Appendix 1. Drawing 103-5170-501, sanitary piping system diagram].

For the distribution of the potable water to the consumers, a supply pressure pump module is installed consisting of three (3) supply pumps, active carbon coal filter, UV sterilization and chlorine sterilization. The water treatment room module with pumps is automatically operated.

The pressure in the system is provided by continuo running at least one pump supported by a small pressure storage tank. In order to keep a constant pressure in the system the pump is to be controlled by automatic sequence depending of the pressure in the system, nominally circa 5 bars. For the distribution of the cold and the hot water, two (2) circulation pumps for each system provided.

The pre-heating of the hot water is arranged by two (2) heat-exchangers from the hot water storage tanks powered by the heat pump units in the engine room. After pre-heating, two (2) boiler tanks are equipped with electric heaters to heat-up the system temperature from preheated 55° C to operating temperature 65° C in one hour. Remote alarm indication of the supply of the hot water lines is provided. High level alarm is 70° C and low level alarm is 50° C.

The system is designed to be operated in different modes using remote controlled valve 066A and manual valves 009A and 011A, as indicated in drawing 103-5710-501 [Appendix 1]. The main modes could be split as indicated in chapter 6.4.

Reference for chapter 6.1: [1] (Henrik Leppänen 2013, Sunborn International)

6.2 Main equipment

Chart 6. List of main equipment with reference to system drawing 103-5710-501 [Appendices 1]. (Sunborn International)

Equipment No.	**Description**	**Capacity**
3.1.5171	Potable water service pumps	20m³/h 6.0bar
5.4.5171	Potable hot water circulating pumps	3.0m³ 3.0bar
7.6.5171	Hot water calorifier	3000L 32.8kW
11.10.5171	Potable cold water circulating pumps	3.0m³/h 3.0bar
5171.12	FW Loading Filter	up to 15.0m³
5171.13	Silver sterilizer	up to 15.0m³
5171.14	Active carbon filter	up to 60.0m³
5171.15	UV sterilizer	up to 60.0m³
5171.16	Chlorine disinfection unit	up to 30.0m³
5171.18	Chlorine disinfection unit	up to 50.0m³
5171.20-21	Pre-heater	348 kW
FW 1S and 1P	Potable Water Storage Tank	117 m³ per tank
FW 2S and 2P	Potable Water Storage Tank	105 m³ per tank

6.3 System diagram

System diagram is indicated in Appendix 1.

6.4 Main operating modes

6.4.1 Bunker operation

The source water to be used as potable water should be provided with sanitary safeguards from the shore side. Potable source water from shore is then treated before bunkering into the four (4) bunker tanks by filtration and silver sterilization and chlorination. Next, bunkered water is supplied through a loading filter and silver ion sterilizer and UV sterilizer [as instructed in chapter 6.7].

Mode: Valve 066A and 011A and all tank valves to be fully open during the operation.

6.4.2 Hotel operation

Gibraltar`s water has been made by reverse-osmosis and therefore should be treated with minerals before supplied to the consumers.[15] (John Collins 2013, James Molinary Ltd.). Since Gibraltar`s water supply is not found to be reliable, water should first be stored into the fresh water tanks [as instructed in chapter 6.7].

Mode: Valve 066A to be normally closed and Valve 009A to be closed.

6.4.3 Disinfection of the storage tanks

The water temperature in tanks (FW 1 P&S and 2 P&S) is to be monitored by remote indicators 24M-27M. Increasing of the water temperature more than 15° C, even for a long period, should be avoided. Temperature of the storage water should be always below 25° C, if higher more than two days then water should be drained completely and tanks should be disinfected by chlorine solution of 50 ppm [super-chlorination instructed in chapter 3.3].

Mode: Valve 066A normally closed and Valve 009A open. The valves before Active Carbon filter 5171.14 closed. Then vendor should complete densification.

Reference for chapter 6.4: [1] (Henrik Leppänen 2013, Sunborn International)

6.5 Interfaces to other systems

For the pre-heating of the sanitary hot water tank, a loop supplied from the hot water storage tank of the heat pump system which is located in the engine room. Pre-heating is then transferred by heat exchangers on both ends of the line.[1] (Henrik Leppänen 2013, Sunborn International)

6.6 Water quality caution

Permanently, according to the flag regulation of the system, the water proved to be potable water quality by using official sampling points, to be tested by independent laboratory. If the storage tanks and the system are even partly out of operation more than two (2) days, cleaned and disinfected according to the regulation [instructed in chapter 3.3] before took in the operation again.

Positive pressure should be maintained in pipelines at all times to prevent the risk of back flow. Generally, connections between potable and non-potable water should not be allowed. Therefore, technical water lines should be always separated. If technical water is not separated, as same as in this sanitary system, then back flow must be prevented with back flush preventers. For this purpose NRV´s are not recommended because the possibility of mal-function. The safest option is to use air cabs (water brakes) because then technical water is fully isolated from the potable water in the system. Air cabs are supplied for this system to isolate all non-potable connections. Only in cases, if air cab can not be used, for example this system`s swimming pool piping connection is pressurized from the potable water line, then should use two (2) of high quality NRV's aligned on line and make sure functionality and cleanliness by everyday checks of equipment.

Reference for chapter 6.6: [1] (Henrik Leppänen 2013, Sunborn International)

6.7 Potable water bunkering instructions

Before source water is supplied into the tanks, water should treated in the Water Treatment Room for adding minerals. The treatment is necessary to avoid rapid corrosion of the copper in piping and for the better taste of the drinking water.[15] (John Collins 2013, James Molinary Ltd.)

The bunkering of water into the storage tanks is monitored only via integrated alarm system (IAS) since manual level gauging is not provided. Valve 066A is opened and water level rise followed from the tank level indicators in Hoppe screen. When 90% of the tank capacity has reached, the bunkering must be stopped. Minimum of 20% of the tank capacity, the distribution system supply module must be stopped and next

bunkering took place. This 20% low limit is required because of Hi-Fog system safety regulations.

Via the IAS, START/STOP is operated for the supply pump module and boilers. Local START/STOP of the system supply module is provided also.

Monitoring of the tank levels and the pump operation via IAS is to be provided. Pressure and temperature indications are to be locally provided. Additional temperature remote indication for the tanks and the hot water supply lines from the boilers is to be provided via IAS.

Vessel bunkering places are provided on both sides (AFT S&P and Bunker Station). Maintenance crew should carry out cleaning around bunkering places and outdoors regarding the source water line. Also, it is recommended to use the Bunker Station onboard for the hygiene reasons. Maintenance crew must be sure that seawater cannot enter bunkering connection or hoses. Also, instructions of potable water bunkering should be followed as instructed in chapter 6.4.1 and 6.8. Safe bunkering rate up to the limit of 15 m^3/h.

Mode: Before starting bunkering from the shore side, valve 066A and 011A and all the tank valves must be fully opened until bunkering is completed.

Also, it is possible to fill up one tank at the time but then there should be continuous monitoring of the water level, and the vessel`s final list has to be calculated before the process is started. Master, or Superintendent if permanently moored, should check from the stability charts the final list in that particular moment by adding weight away from the centre. Also, the weather and seawater level can affect the mooring arms and give extra stress to the structure.

If the source water supply is off-line for long time, then source water can be bunkered from the water tanker ship.

Potable water bunkering check list must be used, as required by Gibraltar Government.

Reference for chapter 6.7: [1] (Henrik Leppänen 2013, Sunborn International)

6.8 Bunkering hose hygiene

Potable water hoses should be kept separately from the other hoses and must be used for potable water only. Should be good durable quality and painted blue, must be tested as leak-proof and to be equipped with proper flanges and adapters & fittings for the shore supply connections. Hoses should be kept in a locker which is marked; ´POTABLE WATER BUNKERING HOSES'. The ends should be capped and stowed after use for avoiding contamination by bacteria or dirt. Hoses should be handled with proper hygiene (hose ends should not lay on a deck or in the ground or should not be in contact with the harbour water) and should be flushed prior bunkering.

A contaminated hose should be disinfected by following instruction:

1. Flush properly with potable water
2. Drain
3. Raise-up both ends
4. Fill up 50 ppm chlorine solution and let effect 1 hour
5. Drain
6. Flush properly with potable water

Reference for chapter 6.8: [2] (WHO 2011, Guide to Ship Sanitation, 28 - 30)

6.9 Water quality inspections

The independent surveyor should check the coating condition and cleanliness of the potable water tanks. The operation must be completed once a year or before or after every repair inside the tank. The tanks must be emptied prior to inspection by pumping all water out. For repairs, only a specialized company and certified materials should be used. After repairs completed, the independent surveyor should carry out final inspection before the tanks taken back in service. The tanks must be disinfected after any operation inside [instructed in chapter 3.3] and prior taken operational, water quality must be checked by independent laboratory. Daily chlorine levels should meet the standard of 0.2 ppm and this check can be done with e.g. colorimeter. Accuracy of the colorimeter must be checked every month with the chlorine standard kit.[14] (The Southern North Sea Pool, Periodical Potable Water Inspection, 1)

Figure 2. Colorimeter.[9] **(**Camlab)

Chart 7. Water quality inspections.

Daily inspection	Daily chlorine levels (should be 0.2 ppm) and temperature measurements of each potable water tank must be noted in the vessel water logbook. Also, the taste and the colour and particles of the water should be checked by the maintenance crew.
Weekly / Monthly inspection	At least every month, but preferable every week, samples should be taken and checked by an independent laboratory for bacteriological analysis. Samples must be taken from each discharge tank of potable water.
Six (6) times in a year inspection	Legionella bacteria samples of the vessel's potable water tanks must be taken to the independent laboratory for testing.

Annual inspection	From each potable water discharge tank, the following samples must be taken by independent laboratory for analysis: physical-chemical, biological and mineral oil (aromatic).
Every 5th year inspection	Pressure tests should be done on all FW tanks. After the pressure test the system must be thoroughly flushed with potable water.
Inspection when re-fitting hotel	The system (from machinery space to furthest outlets) should be charged with super- chlorinated potable water at concentration of 50 ppm for a period of 12 hours and then completely flushed and refilled potable water with 0.2 ppm residual free chlorine.

Reference for chapters 6.9.1 – 6.9.6: [7] (Redditch Borough Council, Water Services)

7 SUNBORN GIBRALTAR SANITARY SYSTEM MAINTENANCE

7.1 Daily check list

As per document, Appendix 2.

7.2 Weekly check list

As per document, Appendix 3.

7.3 Monthly check list

As per document, Appendix 4.

7.4 Half yearly check list

As per document, Appendix 5.

7.5 Yearly check list

As per document, Appendix 6.

7.6 Five yearly check list

As per document, Appendix 7.

8 FUTURE PLANS

8.1 Reverse osmosis potable water production plant

Gibraltar`s local potable water supply is relevantly high-priced and the management of the hotel-ship is planning to build a potable water production plant based on reverse osmosis method from the seawater source, for planning to save some costs. At the time of writing this thesis, these plans were still under progress and the final decision of the reverse osmosis plant had not been done yet.

8.2 Remineralisation

Reverse osmosis water plant should be equipped with remineralisation equipment because the water alkaline should meet Ph levels from 8 to 9 and include magnesium between 20-30 ml/L and calcium between 40-80 ml/L. Then should be corrosion in the copper of piping avoided and the drinking water should be healthy and good tasting.[15] (John Collins 2013, James Molinary Ltd.) and [4] (Frantisek Kozisek 2003, National Institute of Public Health)

9 CONCLUSIONS

Constant supply of the potable drinking water is vital for this five stars hotel-ship. Restaurants cannot work properly if the water to be used for cooking and the production of ice cubes comes in bottles. Also, water distributed into rooms should be practically potable because of five-star classified hotel. Therefore, the storage of the potable water is the only option to ensure constant supply because the history in Gibraltar has shown regular outages in municipal water supply.

Ph level of Gibraltar municipal water can be as low as 6.5. Therefore, the water system should be equipped with additional water treatment equipment e.g. limen stone cartridge for minerals to be added for corrosion of copper to be avoided in the piping system and also to verify the pleasant taste of the drinking water.

Bunkering should be done as instructed and specially, hygiene should be maintained. Bunkering places and hoses should be kept clean and out of dirt, and non-potable water should not be accessed in any case with potable water piping or equipment. If potable water to be contaminated, super-chlorination must be take place. Instructions for these operations should be followed.

Periodical inspections, maintenance, laboratory testing and water log book records of the potable water and distribution system, must be done on regular basis, and instructions should be followed. Also, water log book should be kept updated for the local authorities inspections. After inspection or maintenance inside tank, tanks must be always cleaned and instructions followed.

Potable water systems should be separated from non-potable piping and equipment even if classification requirement does not consider it necessary. Air cabs and NRV`s should be protective but still exists small possibility of potable water can be contaminated during maintenance operations. Therefore, maintenance should be done by professional staff with a wide range of knowledge of the system and requirements.

REFERENCES

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[2] WHO 2011, Guide to Ship Sanitation, 3rd edition, 171 pages.

[3] WHO 2011, Guidelines for drinking-water quality, 4th edition, 564 pages.

[4] Frantisek Kozisek 2003, National Institute of Public Health, Health Significance of Drinking Water Calcium and Magnesium, 29 pages.

[5] WHO 2004, Rolling Revision of the WHO Guidelines Drinking-water Quality, 152 pages.

[6] MCA 2006, MGN 397 (M+F), Guidelines for the Provision of Food and Fresh Water on Merchant Ships and Fishing Vessels, 17 pages.

[7] Redditch Borough Council, Water Services Log Book, Appendix 2, 11 pages.

[8] City of London, London Port Health Authority, A Procedure for the Super-chlorination of Ship's Potable Water Tanks, 1 page.

[9] Camlab, http://www.camlab.co.uk/chlorometer-kit-standard-chlorine-range-p26251.aspx

[10] UnitConversion.org, www.unitconversion.org

[11] WHO, www.who.int

[12] MCA, www.dft.gov.uk/mca/

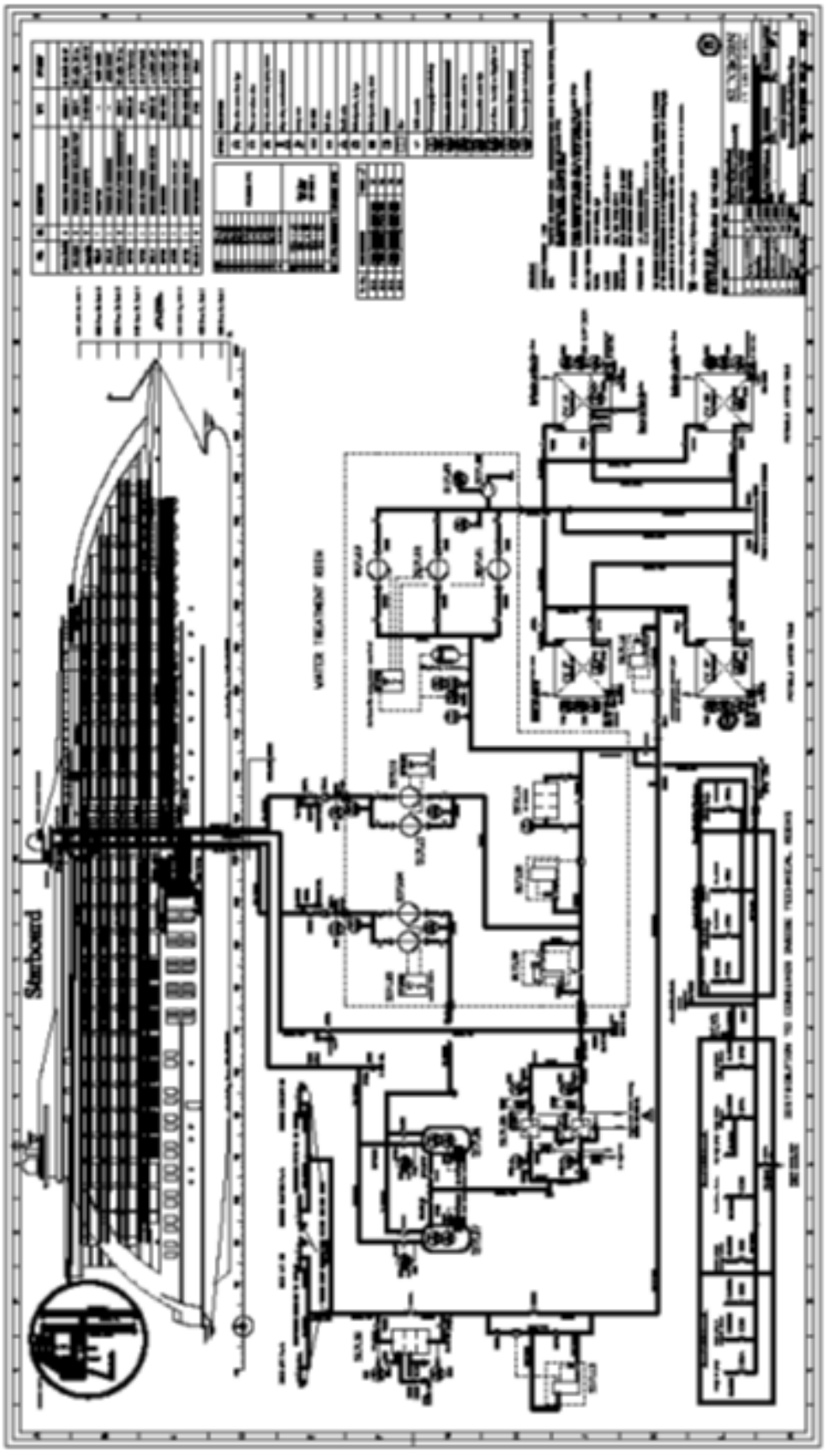
[13] MCA 1986, Department of Transport, Merchant Shipping Notice No. M.1214, 8 pages.

[14] The Southern North Sea Pool, Periodical Potable Water Inspection, 7 pages, www.snspool.com

[15] John Collins 2013, Marine Technical Superintendent, James Molinary Ltd.

APPENDICES

Appendix 1. Drawing 103-5170-501, sanitary piping system diagram.



Appendix 2. Waterlog book, daily check list.

WATER LOG BOOK, DAILY CHECK LIST

POTABLE FRESH WATER AND PIPING

DATE: / /

- ☐ Daily chlorine counts and temperature measurements of each potable water tank must be noted. Also check taste and colour and particles from bright class towards strong light. Follow Sanitary Potable Water manual chapter 9 for potable water inspection procedures. *Clean clothing required!*

  TEST RESULTS

  CLORINE (standard 0,2 ppm = 0,2 mg/L) :
  COLD WATER TEMP. (max 25° C max rice 3° C) :
  HOT WATER CALORIFIER (min 60° C max 65° C):
  COLOR, TASTE AND PARTICLES :

- ☐ Check ships risers for any damage or leaks through corridor access doors.

- ☐ Hi -Fog sprinklers heads cleaning above all kitchen fryers.

- ☐ Inspection of swimming pool system of any damage or leakage and Chlorine test according to supplier Swim Dream instructions.

- ☐ All plant rooms to be checked for any damage or leaks.

- ☐ Check pump and filters are clear and working.

- ☐ Check water treatment room is all correct and working.

- ☐ Check water tanks vent filters are clean and condition of wire cloth is good.

- ☐ Check water levels of tanks. They can not decrease 20% limit.

Inspection done by,

_____

Appendix 3. Waterlog book, weekly check list.

WATER LOG BOOK, WEEKLY CHECK LIST

POTABLE FRESH WATER AND PIPING

DATE: / /

- ☐ All kitchen and bars to be checked for damage on leaks and traps drains made clear. *Clean clothing required!*
- ☐ Rooms to be checked for leakages when possible, and drain few minutes rooms not used lately. *Clean clothing required!*
- ☐ Water samples need to be taken and checked by an independent laboratory for bacteriological analysis, of each potable water discharge tank, as guided in Sanitary Potable Water System manual chapter 9. *Clean clothing required!*
- ☐ Movement of valves on system to be checked against locking.
- ☐ Check pump and filters are clear. *Clean clothing required!*
- ☐ Non return valves in pool system to be checked.
- ☐ Check and record water temperature from sentinel taps;

  Hot water should be over 50° C after one (1) minute flushing

  Cold water should be below 25° C after two (2) minute flushing

Inspection done by,

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Appendix 4. Waterlog book, monthly check list.

WATER LOG BOOK, MONTHLY CHECK LIST

POTABLE FRESH WATER AND PIPING

DATE: / /

- ☐ Carbon filters. Clean or change. Filters should be maintained or replaced according to *Hatenboer Water manual* instructions. *Clean clothing required!*
- ☐ UV sterilizer. Clean according to *Hatenboer Water manual* instructions. *Clean clothing required!*
- ☐ Shower heads for whole hotel. Cleaning by using a 50 ppm chlorine solution. *Clean clothing required!*
- ☐ 6 times a year Legionella bacteria samples of the vessel's potable water tanks has to be taken for checking by independent laboratory.
- ☐ Check and record calorifier temperatures;

  Flow from calorifier in limits of 60 – 65° C

  Return min 50° C

Inspection done by,

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Appendix 5. Waterlog book, half yearly check list.

WATER LOG BOOK, HALF YEARLY CHECK LIST

POTABLE FRESH WATER AND PIPING

DATE: / /

- ☐ Potable FW hoses flushing and filling with 50ppm chlorine solution and allow to stand for at least an hour before emptying and stowage. Detail instruction in chapter 7. *Reference to WHO guide to ship's sanitation for Potable Watering facilities onboard ships.*
- ☐ All water to be drained out of tanks and prior re-filling bottom should be flushed to clear sediment off without opening tank top, means just flush and drain water from system onboard. *Reference to Merchant Shipping Notice No. M.1214.*
- ☐ Measure and record cold water temperature rise between tank outlet and return, should be inside 2 – 3° C limit. *Reference to Merchant Shipping Notice No. M.1214.*

Inspection done by,

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Appendix 6. Waterlog book, annual check list.

WATER LOG BOOK, ANNUAL CHECK LIST

POTABLE FRESH WATER AND PIPING

DATE: / /

- ☐ Calorifiers to be opened up and inspected scaled and cleaned. Before draining temperatures should be raised to 70°C for at least an hour to ensure destruction of bacteria which may have colonised the lower and cooler zone of the unit. *Look detail instructions of over hauling of calorifier from Hatenboer Water manual. Reference to Merchant Shipping Notice No. M.1214.*

- ☐ Tank to be opened and cleaned properly all surfaces with 50 ppm free chlorine solution before flushing and re-filling with 0,2 ppm free chlorine potable water, also inspection of tank construction for cracks and coating damages and of course repairs if necessary by manufacturer or supplier instructions. *Reference to Merchant Shipping Notice No. M.1214.*

- ☐ From each potable water discharge tank, the following samples must be taken by independent laboratory for analysis: Physical-chemical, biological and mineral oil (aromatic).

- ☐ Write report

Inspection done by,

_____

Appendix 7. Waterlog book, 5 yearly check list.

WATER LOG BOOK, 5 YEARLY CHECK LIST

POTABLE FRESH WATER AND PIPING

DATE: / /

- ☐ Draining of whole water system and then pressure testing of all tanks and repairs if needed by vendor.
- ☐ The whole sanitary water system including tanks should be charged of 12 hours with 50 ppm chlorine solution and afterwards properly flushed prior re-filling of potable water with concentration of 0,2 ppm chlorine.
- ☐ Write report

Inspection done by,

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